

Jay Ramasastry	Qualcomm/LQP	202-223-1720/202-833-2161
Brian Ramsay	NTIA	202-482-3180/202-482-4396
Ed Reinhart	Consultant (HAC)	703-448-9552/703-448-5920
Ron Repasi	FCC	202-634-1841/202-634-6625
Beverly Sincavage	LTA for LQP	301-229-9341/301-229-3148
Jim Vorhies	NTIA	202-482-1138/202-482-4396
Warren Richards	U.S. State Dept.	202-647-0049/202-647-7407
Michael Richmond	NTIA	202-482-1164/202-482-4396
Alan Rinker	CSC/NASA	703-834-5606/703-487-9401
Leslie Taylor	LTA	301-229-9341/301-229-3148
Wes Vivian	Wireless Cable Assoc.	202-452-7823/202-452-0041
Alix Watson	AirTouch Comm.	510-210-3439/510-274-4811
Jack Wengryniuk	COMSAT Labs	301-428-5027/301-428-9287
Gerry Wiggen	SFA, Inc.	310-839-5495/301-839-4995

## ATTACHMENT 2

### WRC-95 Advisory Committee Informal Working Group 4 Feeder Links Document List

Doc. No.	Document Title	Date	Originator/Author
IWG-4/1	IWG-4 Terms of Reference	6/16/94	WRC-95 IAC
IWG-4/2 (Rev1)	IWG-4 Work Program	7/5/94	WRC-95 IAC
IWG-4/3	TG 4/5 Draft Contribution to CPM (Doc 4-5/TEMP/14) "Regulatory/Procedural Provisions for Non-GSO MSS Feeder Link Networks"	6/16/94	ITU-R TG 4/5
IWG-4/4	TG 4/5 Draft Contribution to CPM (Doc 4-5/TEMP/16 (Rev 1) "Current Use of FSS Allocations and Related Procedures"	6/16/94	ITU-R TG 4/5
IWG-4/5	TG 4/5 Draft Contribution to CPM (Doc 4-5/TEMP/23) "Characteristics of MSS Feeder Links and Typical GSO/FSS Carriers"	6/16/94	ITU-R TG 4/5
IWG-4/6	TG 4/5 Doc 4-5/TEMP/24 Table Containing Provisional Categorization of FSS Bands Between 3 and 31 GHz	6/16/94	ITU-R TG 4/5
IWG-4/7	Meeting Schedule for IWGs 1-5	7/5/94	WRC-95 IAC
IWG-4/8	Preferred FSS Bands for NGSO MSS Feeder Links	7/5/94	COMSAT Mobile
IWG-4/9	Preferred 20/30 GHz MSS Feederlink Allocation Categories	7/5/94	Jansky/Barmat Telecommunications
IWG-4/10	Rationale for Feeder Link Frequencies	7/5/94	WEC/Ellipso
IWG-4/11	Use of the 5000 to 5250 MHz Band for MSS Feeder Links (FAA Position)	7/5/94	FAA
IWG-4/12	Outline for Report of IWG-4	7/19/94	Chairman IWG-4
IWG-4/13 Rev 1	Spectrum Requirements for MSS Feeder Links (Draft Section 2 to Report)	11/8/94	LTA
IWG-4/14 Rev 1	Revision of Footnote 797A to Permit Use of the 5000-5250 MHz Band for MSS Feeder Links	8/16/94	SatTech Systems/LTA
IWG-4/15	General Comments on Frequency Sharing Between Multiple NGSO/MSS Systems	7/19/94	COMSAT Mobile
IWG-4/16	FSS Bands Not to be Considered in Future IWG-4 Work	8/12/94	Chairman IWG-4
IWG-4/17	Non-GSO Feederlink Issues	8/16/94	COMSAT Mobile
IWG-4/18	Spectrum Requirements for Ellipso (LEO E)	8/16/94	WEC/Ellipso
IWG-4/19	Liaison Note to Chair - IWG-4 MSS Feeder Links in the 13.75-14.00 GHz Band	8/12/94	Chair IWG-5

IWG-4/20	Comparison of Coordination Provisions	8/15/94	COMSAT World Systems
IWG-4/21	Table of Primary and Secondary Allocations in the Frequency Bands Under Consideration for MSS Feeder Links	8/15/94	COMSAT World Systems
IWG-4/22	Table of Coordination Scenarios	8/15/94	COMSAT World Systems
IWG-4/23	Considerations Relating to Choice of Frequency Bands for MSS Feeder Links (Draft Cestion 3 to Report)	10/18/94	WEC/Ellipso
IWG-4/24	Information Only Paper for IAC Use on the 15.4-15.7 GHz Band	11/8/94	WEC/Ellipso
IWG-4/25	Draft Text for Section 6 of IWG-4 Report of WRC-95 IAC	11/8/94	WEC/Ellipso
IWG-4/26	Section 4 of IWG-4 Report: Feeder Link Sharing Feasibility	11/8/94	COMSAT Mobile Communications
IWG-4/27	Characteristics of a proposed Ka-band GSO FSS system to provide global, two-way digital services between very small aperture terminals	10/20/94	Hughes
IWG-4/28	Information Document - Summary of current "Big LEO" proposal for feeder link spectrum	8/11/94	COMSAT Mobile Communications
IWG-4/29	IWG-4 Interim Report	12/13/94	Chairman IWG-4
IWG-4/30	Task Group 4/5 Contribution to the Consolidated CPM Report	12/5/94	ITU-R TG 4/5
IWG-4/31	Draft Text for Section 5 of IWG-4 Report	12/10/94	Teledesic
IWG-4/32	AT&T Proposal concerning the agenda for WRC-97 and the future use of the 5.2 GHz band for high speed wireless data systems	10/12/94	AT&T
IWG-4/33	Reverse Band Working Feeder Links in the 13.75-14.00 GHz Frequency Band Sharing with Radiolocation/Radionavigation Services	9/20/94	DISA
IWG-4/34	Characteristics of a Low Earth Orbit FSS Network for Operation in the Bands 27.5-29.5 GHz and 17.7-19.7 GHz	10/31/94	Teledesic
IWG-4/35	Co-Directional Sharing Between NGSO FSS Systems and NGSO MSS Feeder Links in the 30/20 GHz Band	11/22/94	Teledesic

**FCC INDUSTRY ADVISORY COMMITTEE**  
**FOR THE**  
**ITU 1995 WORLD RADIO COMMUNICATION CONFERENCE**

~ ~ ~ ~

**INTERIM REPORT**  
**OF**  
**INFORMAL WORKING GROUP 5**

~ ~ ~ ~

**Diane Garfield**  
**Chair**

**Jack Miller**  
**Vice Chair**

# **IWG-5 Interim Report to the IAC**

## **Table of Contents**

- 5.1. Introduction**
  - 5.1.1. The Scope of this Report**
  - 5.1.2. Terms of Reference**
  - 5.1.3. Work Program**
    - 5.1.3.1. Agenda Item 2.2**
    - 5.1.3.2. Agenda Item 2.3**
    - 5.1.3.3. Agenda Item 3(b)**
    - 5.1.3.4. Other Matters**
  - 5.1.4. Meetings and Participants**
  - 5.1.5. Report Organization**
- 5.2. Power Limits for Earth Stations in the 2025-2110 MHz Band**
  - 5.2.1. The Issue**
  - 5.2.2. Other Positions and Proposals**
  - 5.2.3. IWG-5 Draft Proposal**
- 5.3. Resolution 112: Use of the 13.75-14.0 GHz Band**
  - 5.3.1. The Issue**
  - 5.3.2. Status and Results of Studies**
  - 5.3.3. IWG-5 Draft Proposal**
  - 5.3.4. Suitability of the 13.75-14.0 GHz Band for MSS Feeder Links**
    - 5.3.4.1. Interference into Radar Receivers**
    - 5.3.4.2. Feeder Link Receiving Earth Station Constraints**
    - 5.3.4.3. Radar Interference into Feeder Link Earth Stations**
    - 5.3.4.4. Interference into Space Science Networks**
    - 5.3.4.5. Assessment**
- 5.4. Issues Considered Under Resolution 712**
  - 5.4.1. The Issues**
  - 5.4.2. Earth Exploration-Satellite and Space Research Satellite Service Allocations in the 8-20 GHz Range**
    - 5.4.2.1. Active Space-Based Sensor Allocations**
    - 5.4.2.2. Passive Sensor Allocations**
    - 5.4.2.3. Non-Sensor Allocations**
  - 5.4.3. Inter-Satellite Service Allocation Near 23 GHz**
  - 5.4.4. 1 GHz Spectrum Allocation Near 35 GHz**
  - 5.4.5. Technical Coordination Parameters in Appendix 28 of the Radio Regulations**
  - 5.4.6. Comments Received to Date in IWG-5**

**5.5. Possible Issues for Future Conferences**

**5.5.1. Introduction**

**5.5.2. Upgrade of the Allocation Status to the Space Research Service in the Band 410-420 MHz**

**5.5.3. Review of the Allocation Status for Active Space-Based Sensors**

**5.5.4. Adoption of Sharing Criteria to Support Space Science Service Operations in the 2025-2110 and 2200-2290 MHz Bands**

**5.5.5. New Primary Allocation to the Inter-Satellite Service in the 61-75 GHz Band**

**5.6. Appendices**

**5.6.1. Proposals and Position Papers**

**5.6.2. List of IWG-5 Participants**

**5.6.3. List of IWG-5 Documents**

**5.6.4. Definition of Terms and List of Acronyms**

## **5. IWG-5 SPACE SERVICES**

### **5.1. Introduction**

#### **5.1.1. The Scope of this Report**

This is the interim report to the Federal Communications Commission (FCC) Industry Advisory Committee (IAC) on the 1995 World Radiocommunication Conference (WRC-95) from Informal Working Group 5, (IWG-5), Space Services. The next WRC is scheduled to convene in Geneva in November of 1995 and will consider a substantive agenda recommended at WRC-93. This report addresses those space service (e.g. space research, space operation, and Earth exploration-satellite) issues which WRC-93 recommended for inclusion on the WRC-95 agenda. Specifically these include: (1) power limits for earth stations in the 2025-2110 MHz Band; (2) consideration of Resolution 112 (WARC-92) dealing with sharing in the 13.75-14.0 GHz band; and (3) Resolution 712 (WARC-92) dealing with space service allocation issues not considered at WARC-92. This report also addresses candidate space service issues for future conference agendas.

The purpose of this report is to assist the FCC in developing U.S. positions and proposals for WRC-95 and in recommending the preliminary agenda items for WRC-97 and WRC-99. This report contains the information, draft proposals and comments received to date in IWG-5 which address the technical and regulatory matters relating to the WRC-95 agenda items listed above, as well as possible future conference agenda items.

Diane Garfield was appointed Chair of IWG-5 and J. E. Miller was appointed Vice-Chair. Steve Sharkey is the Designated Federal Officer.

#### **5.1.2. Terms of Reference**

The Terms of Reference direct IWG-5 to draft and justify for consideration by the Committee of the Whole, recommendations for U.S. proposals and positions related to:

- (1) Power limits for earth stations in the Earth exploration-satellite, space research, and space operation services in the band 2025-2110 MHz;
- (2) Resolution 112 (WARC-92) concerning the use of the 13.75-14.0 GHz band, in light of the results carried out in application of that resolution;
- (3) Issues considered under Resolution 712 (WARC-92) limited to consideration of work carried out by the study groups and the

Conference Preparatory Meeting of the Radiocommunication Sector,  
with a view toward action being taken by WRC-97;

- (4) Related space services matters as specified by the WRC-95 agenda and as approved by the Committee of the Whole.

The recommendations for the U.S. proposals and positions related to the above shall be supported by narrative text indicating the rationale for decisions of this group. Potential issues for future conferences shall be referred to IWG-6, Future Agendas, for consideration.

### **5.1.3. Work Program**

The Work Program of IWG-5 directs that when recommending U.S. positions and proposals the committee should consider the following elements:

#### **5.1.3.1. Agenda Item 2.2**

**Power Limits.** The informal working group is to recommend appropriate power limits for earth stations in the space science services (space research, space operations, and Earth exploration-satellite) allocated to operate on a primary basis in the 2025-2110 MHz band. In recommending power limits, the informal working group is to consider the effects these limits will have on the ability of space science services to share the 2025-2110 MHz band with fixed and mobile services which are also allocated to use this band on a primary basis. Work should not, however, extend to specific sharing issues considered in Resolution 211 (WARC-92). Consideration of Resolution 211 is on the preliminary agenda for WRC-97. The informal working group should identify the effect that use of the 2025-2110 MHz band by the space science services will have on existing or future use of the band by non-government users.

#### **5.1.3.2. Agenda Item 2.3**

**Fixed Satellite Service Use of the Band 13.75-14.0 GHz.** The informal working group is to consider Resolution 112 (WARC-92) and develop recommendations concerning use of the 13.75-14.0 GHz band by the fixed satellite service, including the ability of the fixed satellite service to share the 13.75-14.0 GHz band with other services allocated to use this band, both on a primary and a secondary basis. This should include analysis of all relevant resolutions, footnotes, and studies related to this issue. The informal working group should identify the potential non-government use of this band and the effect that sharing with other services will have on non-government use.



### **5.1.3.3. Agenda Item 3(b)**

**Space Services Allocations.** The informal working group is to consider work related to agenda item 3(b) carried out by the study groups and should identify specific related issues or concerns that may require further study prior to action at a future conference. Action on Resolution 712 is on the preliminary agenda for WRC-97. In identifying issues for further study, particular attention should be given to the effect that recommendations of the study groups will have on present or future non-government use of applicable frequency bands.

### **5.1.3.4. Other Matters**

Any matters that the informal working group believes require further consideration at a future conference but that are not specifically addressed on the WRC-95 agenda or WRC-97 preliminary agenda should be referred to IWG-6, Future Agendas for consideration.

### **5.1.4. Meetings and Participants**

To date IWG-5 has held seven meetings. Participation in the group is open to all persons in both the public and private sectors. A list of meeting attendees is included in Section 5.6.2. Typical meeting attendance has been on the order of ten persons with the division averaging about seventy percent public and thirty percent private sector attendees. While private sector participation has been less than outstanding, recently a consistent core of private sector participants has emerged who are beginning to take initiative on specific issues of interest.

### **5.1.5. Report Organization**

This report is organized into six Sections. Section 5.2 deals with the issue of power limits for Earth stations in the 2025-2110 band. This section includes background on the issue and discussion of a draft proposal which will be finalized following the results of the Joint Ad Hoc Working Party 7B/9D (JWP 7B/9D) meeting this November.

Section 5.3 addresses Resolution 112 dealing with sharing issues in the 13.75-14.0 GHz band. This section covers the background of sharing difficulties encountered between the services in this band (fixed satellite, radiolocation, Earth exploration-satellite and space research). Recommendations prepared by the Radiocommunication Sector of the International Telecommunication Union (ITU-R) to enable sharing between the Fixed-Satellite Service (FSS) and systems in the radiolocation and radionavigation service, and to protect space science use of the band are reviewed. Suppression of Resolution 112 is proposed in light of this work. In addition it addresses one aspect of the suitability of this band as a candidate for Mobile-Satellite Service (MSS) feeder links.

Section 5.4 addresses issues considered under resolution 712 (WARC-92). It is intended that these issues be examined at WRC-95 with the understanding that any substantive action is to be taken at WRC-97. This section discusses the issues contained in Resolution 712, the current status of relevant work in the ITU-R study groups, and includes comment on these issues from the private sector.

Section 5.5 addresses other issues for consideration for future conferences. Several space service issues have been introduced for consideration in information documents to IWG-5. To date, the private sector has commented upon one of these issues, sharing between the Earth Exploration-Satellite Service (EESS) and the Inter-Satellite Service (ISS) in the vicinity of 60 GHz.

Section 5.6 contains four Appendices. Draft proposals and position papers are found in Section 5.6.1. Meeting participants are listed in Section 5.6.2 and a list of IWG-5 documents is in Section 5.6.3. Section 5.6.4 contains a glossary which defines relevant terms and a list of acronyms used in this report.

## **5.2. Power Limits for Earth Stations in the 2025-2110 MHz Band**

### **5.2.1. The Issue**

Item 2.2 of the WRC-95 agenda addresses the issue of power limits for earth stations in the space science services that operate in the 2025-2110 MHz band. At the 1992 World Administrative Radio Conference (WARC-92) new primary allocations were added to the International Table of Frequency Allocations for the space research, space operation and Earth exploration-satellite services for the 2025-2110 MHz and 2200-2290 MHz bands. These bands were already allocated on a primary basis to the fixed and mobile services, except in Region 1 where they were secondary. It is worth noting however that in the United States the 2025-2110 MHz band is allocated to the mobile service on a primary basis. Footnote U.S. 90 limits transmissions in the space research and Earth exploration-satellite services.

WARC-92 did not specify any power limits for earth stations in these services, which raised some concern due to the sharing required with the mobile and fixed services. Radio Regulations Article 28 provides limits for equivalent isotropically radiated power (e.i.r.p.) for earth stations in the frequency bands between 1 and 15 GHz. The services and associated bands for which these limits apply are specified explicitly in RR No. 2547 (S21.12). The space science services are not listed for the 2025-2110 MHz band.

Various sharing issues, including appropriate e.i.r.p. limits for the space services earth stations in the 2025-2110 MHz band are being studied by Joint Ad Hoc Working Party 7B/9D. At present a final value has not yet been decided.\* Preliminary investigation has indicated that the limits of No. 2541 may not be entirely appropriate for the space services.

### **5.2.2. Other Positions and Proposals**

The Interdepartment Radio Advisory Committee (IRAC) has approved release of a preliminary document containing a set of draft recommended proposals for WRC-95. Document No. 23 of this report is a draft proposal for agenda item 2.2, i.e. power limits for earth stations in the space science services in the band 2025-2110 MHz. In this document the U.S. proposes to add No. 2544 bis (6) to Article 28 of the Radio Regulations establishing an exception to the power limits given in No. 2541. At present the upper e.i.r.p. limit is not specified in the draft proposal, pending the results of JWP 7B/9D. This proposal is consistent in approach and content with the draft proposal developed to date in IWG-5 (See Section 5.2.3 and Section 5.6.1).

---

\* During the writing of this report, JWP 7B/9D reached consensus that the power limits specified in No. 2541 are appropriate. As other administrations will undoubtedly submit proposals on this issue, it may be wise strategy for the U.S. to refrain from doing so. A position paper from IWG-5 may offer a suitable alternative. This question will be addressed at a subsequent IWG-5 meeting.

At WRC-93 the Canadians unsuccessfully proposed application of the No. 2541 e.i.r.p. limits to the space research service. Canada was also instrumental in placing this issue on the WRC-95 agenda. There is some speculation that the Canadians may attempt to revive their proposal to apply the No. 2541 limits, particularly should no consensus be reached in JWP 7B/9D. At present the position of other administrations is not known.

### **5.2.3. IWG-5 Draft Proposal**

IWG-5 has developed a draft proposal addressing agenda item 2.2. This proposal is predicated upon the assumption that JWP 7B/9D will reach consensus and agree upon a set of technical parameters which the U.S. can propose to satisfy this agenda item. This draft proposal is consistent in approach with the IRAC proposal discussed above. No. 2544 bis (6) is proposed as an addition to Article 28 of the Radio Regulations. This would establish an exception to the power limits given in No. 2541 for earth stations in the space services operating in the 2025-2110 MHz band. The e.i.r.p. value will be specified following the report from JWP 7B/9D. The IWG-5 draft proposal can be found in Section 5.6.1.

### **5.3. Resolution 112: Use of the 13.75-14.0 GHz Band**

#### **5.3.1. The Issue**

WARC-92 added an allocation to the fixed-satellite service in the frequency band 13.75-14.0 GHz. Radio Regulation 855A places limitations on the fixed-satellite, radiolocation and radionavigation services to enable sharing in the band. Radio Regulation 855B gives equal status to those geostationary space stations in the space research service for which advance publication information had been provided prior to 31 January 1992 and to stations in the fixed-satellite service. It also stipulates that stations in the fixed-satellite service shall not cause harmful interference to non-geostationary space stations in the space research and Earth exploration-satellite services until 1 January 2000.

Resolution 112 invites the ITU-R to study the adequacy of the values given in 855A to enable sharing and to report on its findings at least one year prior to the next competent conference. It also invites studies with regard to the compatibility between systems in the fixed-satellite service and those in the space research and Earth exploration-satellite services. It further calls for review of 855A to be placed on the agenda of the next World Radiocommunication Conference..

Review of Resolution 112 in the light of the results of studies carried out in application of that Resolution and the taking of appropriate action are Item 2.3 on the Agenda for WRC-95.

A new, related issue has emerged due to consideration of the 13.75-14.0.0 GHz band as a candidate band for MSS feeder links.

#### **5.3.2. Status and Results of Studies**

ITU-R Task Group 4/4 was formed to perform the studies related to the values given in RR 855A. Task Group 4/4 has completed its studies and confirmed the values given in RR 855A to be appropriate to enable sharing the 13.75-14.0.0 GHz band between the FSS and the radiolocation service. Recommendation ITU-R S.1068 was developed and approved to provide further detail with respect to sharing between the services. Annex 1 of the Recommendation contains the methods and sharing criteria to be used to compute and assess the interference from radars to fixed-satellite service networks. It further recommends that the design of new transmitters in the radiolocation/radionavigation services should be consistent with these sharing criteria.

ITU-R Task Group 7/3 was established to study the technical compatibility between the primary allocation to the fixed-satellite (Earth-to-space) service and the allocations to the space research and Earth exploration-satellite services. It has also completed its studies.

Task Group 7/3 determined that there is limited compatibility between the primary allocation to the FSS (Earth-to-space) and the secondary allocations to the space research service and the Earth exploration-satellite service in the band 13.75-14.0 GHz after the year 2000. Most active sensor operators will choose to redesign their follow-on instruments, beyond those currently in orbit or planned for launch in the near future, to operate below 13.75 GHz, thus avoiding the possibility of interference from the FSS. One long range problem was identified, however, and that is a necessity to continue operations of NASA's tracking and data relay network into the 21st century. There is also a need to extend operations of the NASA/NASDA planned Tropical Rainfall Measuring Mission (TRMM) precipitation radar until 1 January 2001 in order to complete its mission.

Task Groups 4/4 and 7/3 worked in close cooperation to develop constraints that will permit completion of the space science missions while allowing early entry of the FSS into the 13.75-14.0 GHz band. Recommendations ITU-R S.1069 and ITU-R SA.1071 contain the agreed constraints on the operation of fixed-satellite networks in order to protect the space science systems to beyond the year 2000.

Task Group 7/3 verified that there is a continuing need for the space science services to operate at frequencies in the vicinity of 14 GHz with bandwidths of as much as 500 MHz. It is not necessary that, in the future, the frequencies available for use by the space science services include the 13.75-14.0 GHz band. However, the reduced band of 13.4-13.75 GHz that will be of practical use to the space science services has a bandwidth of only 350 MHz. This unresolved problem and the related issue of primary status for active sensor allocations is being handled under WRC-95 agenda item 3b, consideration of Resolution 712 (See Section 5.4.2 of this report).

#### **5.3.3. IWG-5 Draft Proposal**

Resolution 112 can be suppressed in light of the satisfactory completion of studies carried out by ITU-R Task Groups 4/4 and 7/3 and the adoption of ITU-R Recommendations ITU-R S.1068, ITU-R S.1069 and ITU-R SA.1071. RR 855A and RR 855B should be modified to reflect these results. The IWG-5 draft proposal to accomplish these actions can be found in Section 5.6.1.

The recently released set of IRAC draft proposals includes Document No. 24, a draft proposal dealing with WRC-95 agenda item 2.3, i.e., 13.75-14.0 GHz Band and Resolution No. 112. This proposal also calls for the modification of RR 855A and RR 855B to reflect the Recommendations adopted by the Radiocommunication Sector, and for the suppression of Resolution 112 in light of the completion of the work envisioned under that Resolution.

#### **5.3.4. Suitability of the 13.75-14.0 GHz Band for MSS Feeder Links**

The band 13.75-14.0 GHz has been identified as a possible down-path for feeder links in the mobile-satellite service. This use would be in the reverse direction to

the current allocation for the fixed-satellite service (Earth-to-space). The band is also allocated to the radiolocation and radionavigation services on a primary basis and to the space research and Earth exploration-satellite services on a secondary basis. There are potential interference situations that would be created were the band to be allocated for MSS (space-to-Earth) and which have a bearing on the suitability of such an allocation.

#### **5.3.4.1. Interference into Radar Receivers**

Interference into radar receivers has been studied and reported in Documents USWP 4A/3 and USTG 4-5/3. Maintaining interference into radar receivers at an acceptable level would require imposition of an aggregate power flux density (pfd) limit at the surface of the Earth of -162 dB (W/m<sup>2</sup>/4 kHz). Since coordination is totally impractical for interference into radars, this pfd limit should not be exceeded.

#### **5.3.4.2. Feeder Link Receiving Earth Station Constraints**

Minimum earth station antenna diameters have been calculated that would conform to a pfd limit of -162 dB (W/m<sup>2</sup>/4 kHz). It was determined that for a geostationary satellite with a 3 dB coverage contour, the minimum diameter would be 5.26 meters. For non-geostationary satellites the minimum diameter depends on a number of factors including the orbit, satellite antenna gain pattern and down-link power control. If the satellite e.i.r.p. is constant with respect to the Earth's surface and the orbit is circular, the minimum antenna diameter ranges from 19.2 meters for a 500 km orbit to 5.6 meters for a 10,000 km orbit. It is obvious that satellite antenna beam shaping and/or satellite power control would be required in order to meet the pfd limits with reasonable size earth station antennas.

#### **5.3.4.3. Radar Interference into Feeder Link Earth Stations**

High power radars on ships operate in this band. Lower power radars are land based and/or carried on aircraft. It appears that feeder link earth stations can be protected from interference from ship radars but only by provision of adequate site shielding between a feeder link earth station and navigable waters.

There is also a potential for interference from land based or aircraft based radars. The degree of interference is dependent on a highly localized environment and would have to be assessed on a case-by-case basis.

#### **5.3.4.4. Interference into Space Science Networks**

RR 855B provides protection for low orbiting satellites in the Earth exploration-satellite and space research services until 1 January 2000. The potential for harmful interference into these satellites has not been evaluated but would need to be taken into account in any near-term plans to implement feeder links for the MSS. A longer term situation is the need to continue to operate NASA's Tracking and Data

Relay Satellite System (TDRSS) into the 21st century. The potential for interference into the forward links of this system needs to be assessed as part of an evaluation of the suitability of the 13.75-14.0 GHz band for MSS feeder links.

#### **5.3.4.5. Assessment**

A requirement to coordinate between radars and the MSS could not be accepted by radar operators.

Imposition of a pfd limit could preclude unacceptable interference into radars. However, the necessary limit would impose significant limitations on the minimum earth station antenna sizes that could be used by the MSS.

Unacceptable interference into feeder link earth stations caused by ship based radars can be virtually eliminated through use of appropriate siting and shielding of the earth station. The likelihood of interference from land based and aircraft based radars is more problematic and depends on localized conditions that would require case-by-case evaluation.

The potential for unacceptable interference from MSS feeder links to space science systems has not been analyzed but needs to be taken into account.

From a U.S. position standpoint, the WARC-92 objective still applies, i.e., to minimize the use of the 13.75-14.0 GHz band by the FSS, including feeder links. ITU-R studies and Recommendations were based on statistical analyses. Increasing FSS usage of the band increases the probability of mutually unacceptable interference.

TG 4/5 has retained this band as a possibility for feeder links under the pfd conditions stated above. This will be included in the Report to the Conference Preparatory Meeting (CPM).



## **5.4. Issues Considered Under Resolution 712**

### **5.4.1. The Issues**

Agenda item 3 for WRC-95 instructs the conference to consider Resolution 712 (WARC-92), taking into account the work carried out by the study groups and the Conference Preparatory Meeting of the Radiocommunication Sector, with a view to WRC-97 taking action, as appropriate. Resolution 712 was adopted at WARC-92 and placed on the WRC-95 agenda at WRC-93. It directs the conference to consider the following matters relating to allocations for the space science services:

- (1) use of existing allocations in the 8-20 GHz range to the Earth exploration-satellite and space research services, with a view to establishing common worldwide primary allocations to these services in appropriate bands;
- (2) additional inter-satellite service requirements for up to 50 MHz of spectrum near 23 GHz;
- (3) provision of up to 1 GHz of frequency spectrum around 35 GHz for use by space-based active earth sensors;
- (4) inclusion of CCIR-approved technical coordination parameters in Appendix 28 of the Radio Regulations.

It is understood that the examination of these issues at WRC-95 will be limited to consideration of the work carried out to date by the various study groups. Any necessary action will be taken at WRC-97 as part of that conference's overall consideration of space science issues. Each of these issues is elaborated below.

### **5.4.2. Earth Exploration-Satellite and Space Research Satellite Service Allocations in the 8-20 GHz Range**

#### **5.4.2.1. Active Space-Based Sensor Allocations**

Allocations for use by active space-based sensors are for the most part by footnote. In the 8-20 GHz range, only one allocation, 17.2-17.3 is in the Table of Frequency Allocations. Consequently most active sensor allocations are not visible in a cursory review of the Table. Moreover, in most cases where allocations do exist, they are secondary in status, and in all cases are shared with (primary) terrestrial radiolocation or radionavigation services. At recent radio conferences (i.e. WARC-92) the radiolocation and radionavigation service allocations have been seen as vulnerable targets by spectrum seekers in search of new allocations (e.g. 13.75-14.0 GHz and 24.25-25.25 GHz.) In this environment, the future viability of active sensing from space is in jeopardy.

With the majority of space-based sensor allocations being invisible due to their allocation by footnote, they do not offer an effective deterrent to those seeking new and vulnerable targets. Once a band has been targeted by users seeking new spectrum, the defensive battle fought by space-based users is usually a losing proposition. Much greater protection could be afforded to both radiolocation, radionavigation and active space-based sensor systems if they were accorded joint primary status in the Table; neither would be easily overlooked by spectrum seekers.

Consideration of upgraded allocations for active spaceborne sensors in the frequency range spanned by Resolution 712 is appropriate at WRC-97. These bands include 8500-8650 MHz, 9500-9800 MHz, 13.25-13.4 GHz, 13.4-13.75 GHz and 17.2-17.3 GHz. The feasibility of primary allocations in common frequency bands for both active spaceborne sensors and radionavigation and radiolocation services requires that systems be compatible without the necessity for constraints on any of the services. ITU-R Joint Working Party (JWP) 7/8R has been established to study this subject. JWP 7/8R has had one meeting where considerable progress was made in examining compatibility in the bands 13.25-13.4 GHz, 13.4-13.75 GHz and 9500-9800 MHz. The JWP has prepared a report to CPM-95 which presents the status of work to date and defines the work that remains to be done. The JWP has prepared a work program that should ensure that its assigned work will be completed in time for inclusion of its findings in the report of the 1997 Conference Preparatory Meeting to WRC-97.

#### **5.4.2.2. Passive Sensor Allocations**

The Earth exploration-satellite service (passive) allocation status in the 18.6-18.8 GHz band is primary in Region 2 and secondary in Regions 1 and 3. This band is one of several frequency bands which are critical for performing ecologically important simultaneous measurements of land and ocean surface phenomena.<sup>\*</sup> It is being implemented on an increasing number of Earth exploration satellites. The 18.6-18.8 GHz band is mentioned specifically in considerings "d" of Resolution 712 and consideration of an upgrade to a uniform, worldwide primary status is appropriate.

The feasibility of sharing among the services allocated to use the band (fixed, fixed-satellite, mobile, Earth exploration-satellite and space research) depends upon adoption of constraints on the technical parameters of fixed, fixed-satellite and mobile systems. Suitable constraints are included in the U.S. domestic allocation tables. Sharing criteria for the space science services sharing with the fixed and fixed-satellite services have been developed and considered in ITU-R Working Party (WP) 7C. A suitable recommendation is to be prepared.

---

<sup>\*</sup> Simultaneous measurements are required to isolate individual phenomena from the composite phenomena resulting from multiple effects.

There are two other passive sensor allocations in the frequency range 8-20 GHz: 10.6-10.7 GHz and 15.2-15.4 GHz. While these bands should be reviewed with regard to allocation status, interference and sharing criteria, there has been no suggestion that these are inadequate for the requirements identified to date. A proposal to modify any of these allocations is not anticipated.

#### **5.4.2.3. Non-Sensor Allocations**

The 8025-8400 MHz communication band is the only band available for wideband EESS data downlinking below 65 GHz. It is vital to both government and non-government users. Unfortunately the Earth exploration-satellite service allocation (space-to-Earth) at 8025-8400 MHz is complex and non-uniform worldwide. Only in Region 2 is the EESS allocation primary. In Regions 1 and 3 EESS is a secondary service, although in certain countries it is primary subject to the provisions of Article 14. In terms of allocated services however, the sharing situation in all three regions is identical. Moreover, telemetry data from earth sensing satellites has been successfully transmitted to Earth in all three regions for many years.

This band is specified in considerings "b" of Resolution 712 and consideration of an upgrade to a uniform, worldwide primary status is appropriate. Its current allocation status was achieved at WARC-79 and most of the sharing criteria were developed prior to that time. Updated sharing parameters were recently published in ITU-R Recommendation IS.849-1 and these should be incorporated into Appendix 28 of the Radio Regulations.

The frequency bands 12.75-13.25 GHz (space-to-Earth) and 16.6-17.1 GHz (Earth-to-space) are allocated to the space research service restricted to deep space operation only in each band. Technical studies have shown that the bands in the vicinity of 32-34 GHz are more suitable for deep space operations. Moreover, the sharing situation at 13 and 17 GHz would be simpler with space research operations not limited to deep space, i.e., if the deep space restriction were removed and the less stringent non-deep space criteria were to be applied. If the band were also considered for upgrade to primary status in addition to removing the deep space restriction, the issue could be treated under Resolution 712 at WRC-97. Studies are underway to demonstrate the improved sharing which will result from such a modification and will be submitted to the CPM and ITU-R study groups.

#### **5.4.3. Inter-Satellite Service Allocation Near 23 GHz**

Considerings "e" of Resolution 712 stated that the current inter-satellite service allocation at 22.55-23.55 GHz was insufficient to ensure full interoperability between data relay satellite systems. An allocation of an additional 50 MHz of spectrum had been proposed at 23.55-23.6 GHz. NASA has indicated that it is no longer interested in an additional inter-satellite service allocation at 23.5-23.6 GHz. The proposed allocation has proven to be incompatible with the adjacent passive

sensor allocation at 23.6-24.0 GHz. Moreover, recent channel plans coordinated with all planned data relay satellite systems in the 22.55-23.55 GHz band indicate that the current allocation is sufficient to address known requirements.

The band 22.55-23.55 GHz is shared among data relay satellite systems and Low Earth Orbit (LEO) mobile-satellite systems operating crosslinks in the inter-satellite service. It has been noted that band segmentation is a feasible approach to the sharing situation. If all MSS systems could be accommodated in the 22.55-22.81 GHz range, then the current and future data relay satellite requirements could be satisfied in the 22.81-23.55 GHz range.

#### **5.4.4. 1 GHz Spectrum Allocation Near 35 GHz**

In the 35 GHz region, future requirements for active Earth-sensing to monitor environmental data, have been identified. The 100 MHz bandwidth available in the existing allocation at 35.5-35.6 GHz is insufficient to accommodate these requirements. Up to 1 GHz of spectrum for space-based active earth sensors in the vicinity of 35 GHz has been suggested to meet these future needs. Recent developments in active sensing technology and studies carried out in support of Task Group (TG) 7/3, suggest that bandwidths of less than 1 GHz may be adequate to meet future requirements; 500 MHz may be sufficient.

#### **5.4.5. Technical Coordination Parameters in Appendix 28 of the Radio Regulations**

ITU-R Recommendation IS.849-1 presents a new method for calculating the coordination distances for earth stations operating with low earth orbiting satellites. This methodology more accurately reflects the gain dynamics of LEO satellites (e.g., significant, predictable variation over time coupled with low transmission loss in the same azimuth) and should be incorporated into Appendix 28 of the Radio Regulations.

Earth stations in the Earth exploration-satellite service and meteorological-satellite services are required to coordinate with fixed-satellite earth stations and fixed stations in the frequency bands 1670-1710 MHz and 8025-8400 MHz. Coordination parameters are published in ITU-R Recommendation IS.849-1 and should be incorporated into Appendix 28 of the Radio Regulations.

#### **5.4.6. Comments Received to Date in IWG-5**

To date only one of the issues in Resolution 712 has been formally commented upon in IWG-5. Orbital Sciences Corporation ("Orbital") has submitted a paper supporting all efforts for a worldwide upgrade to the Earth exploration-satellite service allocation in the 8025-8400 MHz band and has recommended that IWG-5 support a similar recommendation by NASA to the IRAC. Lockheed had indicated

support for the same issue but to date no paper has been submitted. The Orbital paper [IWG-5/36] is contained in Section 5.6.1.

## **5.5. Possible Issues for Future Conferences**

### **5.5.1. Introduction**

Several additional space service issues have been presented to IWG-5 for consideration. Although not now on any WRC agenda, these items are candidate issues for future conferences, in particular WRC-97. At present, one issue, a new allocation to the inter-satellite service near 60 GHz, has generated written support from IWG-5 private-sector participants. A list outlining the items under consideration has been forwarded to IWG-6, Future Agendas. These issues include:

- (1) Upgrade of the allocation status to space research service in the band 410-420 MHz;
- (2) Review of the allocations status for active space-based sensors;
- (3) Adoption of sharing criteria to support space science service operations in the 2025-2110 and 2200-2290 MHz bands;
- (4) New primary allocation to the inter-satellite service in the 65-71 GHz band.

### **5.5.2. Upgrade of the Allocation Status to Space Research in the Band 410-420 MHz**

The 410-420 MHz band is allocated to the space research service on a secondary basis. The primary U.S. Space Program use would be for astronauts engaging in space-to-space communication within 5 km of a manned space station (e.g. walks outside the space station). The space agency of at least one other administration is planning to make use of this band. In this event, power flux density constraints would be needed to protect existing U.S. terrestrial fixed and mobile systems.

Since the present allocation to the space research service is secondary, the burden of establishing the source of interference to a primary service (so that a shutdown might be effected) is on the primary service. Once power flux density limits are established, the responsibility to comply with those limits is on the space research (i.e., co-primary) user. The result is a known, friendlier environment. Establishment of pfd limits and upgrade to primary service are concomitant events. In the face of increasing competition for spectrum, adequate allocation status is required to: (1) protect the existing allocations to FSS and MSS in this frequency band, and (2) protect U.S. Space Program investment.

Sharing conditions are under review based on the work carried out in preparation for JIWP-91. Analysis is being conducted in Study Group 7 to establish appropriate pfd limits. These findings will be submitted to the Radio Conference Subcommittee (RCS) as well as the National Committee prior to submission to ITU-R SG 7. Results of this work are anticipated in early 1995.

### **5.5.3. Review of the Allocations Status for Active Space-Based Sensors**

The need to establish common worldwide primary allocations to the Earth exploration-satellite service for use by active space-based earth sensors has been discussed previously in Section 5.4.2. Much greater protection could be afforded to both terrestrial radiolocation/radionavigation systems and to active spaceborne sensors if there were common primary frequency allocations in the Table of Frequency Allocations. The common primary frequency allocations would help to protect all these services from pressure brought by expanding requirements of other services.

Resolution 712 is on the preliminary agenda for WRC-97 and proposes a review of allocations to the Earth exploration-satellite service and the space research service in the frequency bands between 8-20 GHz with a view to establishing common worldwide primary allocations to these services in appropriate bands. There are several active sensor allocations falling outside this frequency range which also need to be considered. These include 1215-1300 MHz, 3100-3300 MHz, 5250-5350 MHz, 24.05-24.25 GHz and 78-79 GHz. WRC-97 may provide a timely opportunity to do so, particularly in light of the analogous treatment of allocations in the 8-20 GHz band.

As in the 8-20 GHz case, primary allocations for active sensors depend upon compatibility between the sensors and the existing terrestrial systems (radiolocation or radionavigation) in any given frequency band. Such studies are under way now in Joint Working Party 7/8R on a band-by-band basis. However, the JWP has already developed representative technical characteristics for Synthetic Aperture Radars (SAR) for the 1215-1300 MHz and 5250-5350 MHz bands and has reviewed the operational experience gained from operation of altimeters and scatterometers in the 5250-5350 MHz band. No instances of unacceptable interference have been identified in either band. This information has been reported to CPM-95. Since JWP 7/8R expects to complete its work in time for inclusion of its findings in the report of the 1997 Conference Preparatory Meeting to WRC-97, it would be feasible to review all active sensor allocations at the 1997 WRC.

Two additional frequency bands, currently unallocated for active sensing, have been identified as necessary for future active spaceborne sensor applications. An allocation in the vicinity of 420-450 MHz is needed, primarily for soil moisture measurements. Also, it has been determined that a frequency band near 95 GHz would be more suitable for cloud radar operations than the existing allocation at 78-79 GHz. It would be desirable to investigate substitution of an allocation at 95 GHz for the one at 78 GHz.

### **5.5.4. Adoption of Sharing Criteria to Support Space Science Service Operations in the 2025-2110 and 2200-2290 MHz Bands**

Operations of all services currently using these bands (e.g. fixed, mobile, and the

space science services) will benefit from established sharing criteria. At this time the necessary studies are underway regarding the sharing criteria between the space science services and the fixed service in these bands. ITU-R Task Group 7/1 has completed its studies on space science and mobile service sharing within these bands. Joint Working Party 7B/9D is examining sharing between the space science and fixed services. Upon completion of this work it may be an appropriate time to incorporate the results into the Radio Regulations. Mobile service sharing criteria in these two bands is already addressed in Resolution 211 which is contained in WRC-97 agenda item 2.1.

#### **5.5.5. New Primary Allocation to the Inter-Satellite Service in the 65-71 GHz Band**

Unique oxygen absorption lines exist in the frequency bands between 50.2 and 65 GHz. Recognizing the value of this singular scientific resource, WARC-79 allocated the bands 50.2-50.4 GHz and 51.4-59.0 GHz to the Earth exploration-satellite service (passive) to be used for the atmospheric temperature measurements necessary for weather forecasting and climate studies.\* Unfortunately, the entire bands are not allocated on an exclusive basis.

The band 54.25-58.2 GHz is allocated on a co-primary basis to the inter-satellite service and may be used by satellite systems for inter-satellite links (ISLs) i.e., crosslinks which interconnect one or more satellites in a constellation. One commercial LEO satellite system is considering use of the inter-satellite service allocation in the 56.75-57.75 and 59.0-60.0 GHz bands to implement satellite-to-satellite crosslinks and to provide message routings between multiple points on the Earth. This system will require bandwidths on the order of 1 GHz in each of the transmit and receive directions initially, with predicted requirements growing to 3 GHz in the foreseeable future.

It is worth noting that the commercial LEO system in question has already been requested to reposition its ISL frequencies from the 59.5-60.5 and 62.5-63.5 bands which are named in the present application to the FCC. This request is the result of a frequency overlap with another inter-satellite service user in the 59-64 GHz band. This band is heavily used by government systems, and NASA has plans for data relay satellite systems which will use most of the available bandwidth. The 56.75-57.75 and 59.0-60.0 GHz bands have come under consideration as an alternative.

Additional LEO satellite commercial providers are expected to file for FCC licensing in the near future. The anticipated large number of active transmitters in Low Earth Orbit have the potential to interfere with the passive earth sensors operating in the 54.25-58.2 GHz band. This use, coupled with use of the band by terrestrial fixed

---

\* The World Meteorological Organization (WMO) has a requirement for atmospheric temperature profiles to be produced to an accuracy of 1 Kelvin at altitude intervals of 1 kilometer.



and mobile services could render the band unusable for atmospheric sensing measurements by the Earth exploration-satellite service.

The band 65-71 GHz has been proposed as a useful alternative for commercial LEO satellite crosslinks. Such an allocation would require demonstration of the feasibility of sharing with the existing allocated service systems. If preliminary coordination does not reveal any major obstacles it may be proposed that a future WRC agenda include allocation of the 65-71 GHz band to the inter-satellite service with co-equal primary status.

#### **5.5.5.1 The Teledesic Corporation Paper**

Teledesic Corporation has introduced a document into IWG-5 [IWG-5/35] which supports the inclusion on the WRC-97 agenda of an allocation of the 65-71 GHz band to the inter-satellite service on a co-primary basis. That paper is contained in Section 5.6.1.